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PAPER XIII

Studies on the Influence of Radiostrontium upon the Blood and Bone Marrow Picture of Rabbits

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INTRODUCTION

It has been shown that radiostrontium was contained in the radioactive ashes collected from the No. 5 Fukuryu Maru.¹⁾ Radiostrontium is readily absorbed from the digestive tract, rapidly concentrates in the skeleton, and once deposited in the skeleton, it is very slowly excreted with a biological half-life of 3.9×10^3 days²⁾. Sr^{89} has a half life of 53 days and emits beta rays with an energy maximum of 1.5 Mev. Sr^{90} has a half life of 19.9 years and emits beta rays with an energy of 0.54 Mev. Taking these factors into consideration, radiostrontium is considered to be one of the most dangerous radioisotopes among the fission products as a source of internal radiation hazards. The toxicity of radiostrontium in experimental animals has been studied by many investigators³⁾. A reduction in circulating polymorphonuclears is said to be the most sensitive indicator of acute and subacute effects of radiostrontium (Simmons, 1947)³⁾. In mice such changes follow the injection of $0.068 \mu\text{C./g.}$ More marked effects, influencing the lymphocytes also, are seen with increasing dosage. In rats the minimal dose required to produce a hematologic effects is $0.22\text{--}0.25 \mu\text{C./g.}$, and in rabbits $1.0 \mu\text{C./g.}$ In this paper is reported the influence of internally deposited radiostrontium upon the blood and bone marrow pictures of rabbits.

MATERIALS AND METHODS

As experimental animals two male adult rabbits weighing about 2 kg. were used. The radiostrontium used was a mixture of Sr^{89} and Sr^{90} supplied by the U. S. AEC. Five hundred $\mu\text{C.}$ of the radiostrontium in the form of strontium chloride in physiologic saline solution were injected intravenously into the rabbits, and the blood and bone marrow pictures were examined at certain intervals for 40 days following the injection.

RESULTS

1) Blood picture (Tables 1, 2 and Figures 1, 2).

The red cell count showed no remarkable change in one case (No. 2). In the other case (No. 1) the red cell count decreased slightly at the first week and then

Influence of Radiostrontium upon the Blood and Bone Marrow Picture

Table 1. Changes of the blood picture of rabbits following intravenous injection of 500 μ C. of Sr ^{89,90} (Rabbit No. 1)

Time			Days before injection			Days after injection										
			3	2	1	1	3	5	7	10	15	16	20	25	30	40
Red cell count (10 ⁴)			589	584	567	590	553	536	548	537	630	638	649	622	603	609
Hemoglobin (%)			100	100	98	102	100	102	100	100	110	110	110	112	114	114
Reticulocyte (‰)			14	17	19	33	24	32	41	56	58		35	32	18	15
Platelet count (10 ⁴)			66.4	63.6	57.2	77.3	73.6	73.2	82.2	57.4	43.4	54.2	56.4	45.4	55.3	40.8
Leukocyte count			9,400	11,200	9,550	11,900	9,900	8,100	10,000	6,800	4,300	4,000	4,700	10,000	9,900	6,200
Differential count																
Pseudoeosinophils	Metamyelocytes		0		0	0	0	0	0	0	0	0	1.0	0	0	0
	Staff cells		14.0		16.0	21.0	16.5	15.5	13.5	16.0	18.0	24.5	42.5	40.5	30.5	26.5
	Polymorpho- nucleurs	2. lobes	25.0		26.5	23.0	18.5	25.5	21.5	22.5	21.5	23.5	21.0	33.0	38.0	27.5
		3 //	4.0		2.5	5.0	3.5	4.0	6.0	2.0	2.0	6.0	1.5	6.0	5.0	5.5
		4 //	0		0	0	0.5	0.5	0.5	0	0.5	1.0	0.5	0	0	0.5
		5 //	0		0	0	0	0	0.5	0	0	0	0	0	0	0
	Total		43.0		45.0	49.0	39.0	45.5	42.0	40.5	42.0	55.0	66.5	79.5	73.5	60.0
	Absolute number		4,400		5,040	5,940	3,860	3,680	4,200	2,820	1,800	2,200	3,080	7,950	7,340	3,710
	Mean nuclear count		1.76		1.70	1.67	1.71	1.74	1.88	1.68	1.64	1.66	1.39	1.58	1.65	1.66
	Eosinophils			2.5		1.5	0.5	0.5	1.0	0	0	1.5	0.5	0	0	0
Absolute number			235		168	59	49	81	0	0	64	20	0	0	0	30
Basophils			4.5		5.5	4.0	4.5	5.0	4.5	2.5	9.0	10.5	1.0	2.5	3.5	5.0
Absolute number			420		616	476	445	405	450	170	388	420	470	250	340	310
Lymphocytes	Small		7.0		3.5	10.0	8.0	1.5	4.5	4.5	7.5	3.0	4.5	3.0	10.0	3.0
	Middle		38.5		41.5	31.0	41.5	36.0	44.0	43.0	32.0	24.0	20.5	10.5	7.0	25.0
	Large		2.5		2.0	1.5	3.0	5.5	2.0	3.0	2.0	1.5	3.5	1.0	1.0	3.5
	Total		48.0		47.0	42.5	52.5	43.0	50.5	50.5	41.5	28.5	28.5	14.5	18.0	31.5
	Absolute number		4,510		5,260	5,060	5,200	3,480	5,000	3,440	1,780	1,140	1,340	1,450	1,770	1,950
Monocytes			2.0		1.0	4.0	3.5	5.5	3.0	6.5	6.0	5.5	4.0	3.5	4.0	3.0
Absolute number			188		112	476	365	445	300	442	258	220	188	350	400	185
Plasma cells			0		0	0	0	0	0	0	0	0	0	0	0	0
Absolute number			0		0	0	0	0	0	0	0	0	0	0	0	0

increased slightly over the initial value. The hemoglobin content increased slightly in both cases in and after the third week following the injection. The reticulocyte count increased after the injection in both cases until the third week and then returned to the initial value. The leukocyte count showed a moderate decrease in the third week and then returned to the initial value in the fourth week in one case (No.1). In the other case the leukocyte count increased slightly in the second week

and then returned to the initial value. In case No. 1, which showed a moderate decrease in the leukocyte count, both the pseudoeosinophils and lymphocytes decreased in number, and the leukopenia was accompanied by a shift to the left of the mean nuclear count of the pseudoeosinophils. The eosinophils showed a tendency to decr-

Table 2. Changes of the blood picture of rabbits following intravenous injection of 500 μ c. of Sr^{89,90} (Rabbit No. 2)

Time		Days before injection			Days after injection											
		3	2	1	1	3	5	7	10	15	16	20	25	30	40	
Red cell count (10 ⁴)		552	553	562	558	567	560	578	567	556	579	576	560	580	569	
Hemoglobin (%)		100	100	100	100	100	100	100	100	102	102	100	104	104	106	
Reticulocyte (‰)		7	10	11	32	30	38	48	43	46		20	17	19	13	
Platelet count (10 ⁴)			66.9	73.6	85.1	83.1	91.0	108.4	107.1	71.3	74.8	72.1	65.1	54.7	53.5	
Leukocyte count		9,200	7,200	6,550	9,600	8,300	7,400	10,700	13,000	8,700	8,400	8,800	9,600	8,500	6,900	
Differential count																
Pseudoeosinophils	Metamyelocytes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Staff cells	26.5	21.0	17.5	32.0	31.5	31.5	31.0	22.0	35.5	25.5	28.5	32.0	23.5	24.0	
	Polymorpho-nuclears	2 lobes	21.0	26.0	18.0	27.5	15.5	18.5	23.0	18.0	30.5	21.5	21.0	28.5	22.5	17.5
		3 "	3.0	5.5	0.5	3.0	2.5	2.0	3.0	1.0	1.5	3.5	4.0	5.0	2.0	1.0
		4 "	0	1.0	0	0	1.0	0	0	0.5	0	0.5	0	0	0.5	0
		5 "	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	50.5	53.5	36.0	62.5	50.5	52.0	57.0	41.5	67.5	51.0	53.5	65.5	48.5	42.5	
	Absolute number	4,600	3,850	2,360	6,000	4,200	3,850	6,100	5,400	5,870	4,280	4,700	6,300	4,200	3,000	
	Mean nuclear count	1.60	1.72	1.53	1.53	1.42	1.47	1.50	1.51	1.50	1.59	1.54	1.58	1.58	1.46	
Eosinophils		3.5	3.0	2.0	1.5	0	0.5	1.0	1.5	0.5	0.5	2.5	0	0	2.0	
Absolute number		320	216	130	145	0	37	108	195	43	42	220	0	0	138	
Basophils		3.0	3.5	5.0	2.5	0.5	3.0	12.0	13.5	6.5	8.5	10.0	6.5	7.0	4.0	
Absolute number		320	250	327	240	41	222	1,280	1,750	565	714	880	625	595	275	
Lymphocytes	Small	2.0	1.5	2.5	3.0	0.5	3.5	1.0	0	1.5	1.5	0.5	3.5	2.5	3.5	
	Middle	36.5	32.5	45.5	25.5	40.0	36.0	24.5	31.0	20.0	28.5	27.0	18.5	35.5	39.5	
	Large	3.0	4.0	5.0	4.5	5.0	1.5	2.5	8.0	2.0	8.0	4.0	2.5	2.0	4.0	
	Total	41.5	38.0	53.0	33.0	45.5	41.0	28.0	39.0	23.5	38.0	31.5	24.5	40.0	47.0	
Absolute number		3,820	2,730	3,470	3,170	3,780	3,040	3,100	5,070	2,050	3,200	2,770	2,350	3,400	3,200	
Monocytes		1.5	2.0	4.0	0.5	3.5	3.5	2.0	4.5	2.0	2.0	2.5	3.5	4.5	4.5	
Absolute number		140	144	262	48	290	260	214	585	174	168	220	336	380	310	
Plasma cells		0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Absolute number		0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Influence of Radiostrontium upon the Blood and Bone Marrow Picture

Fig. 1. Changes of the blood picture of rabbits following intravenous injection of 500 μ c. of Sr ^{89,90} (Rabbit No. 1)

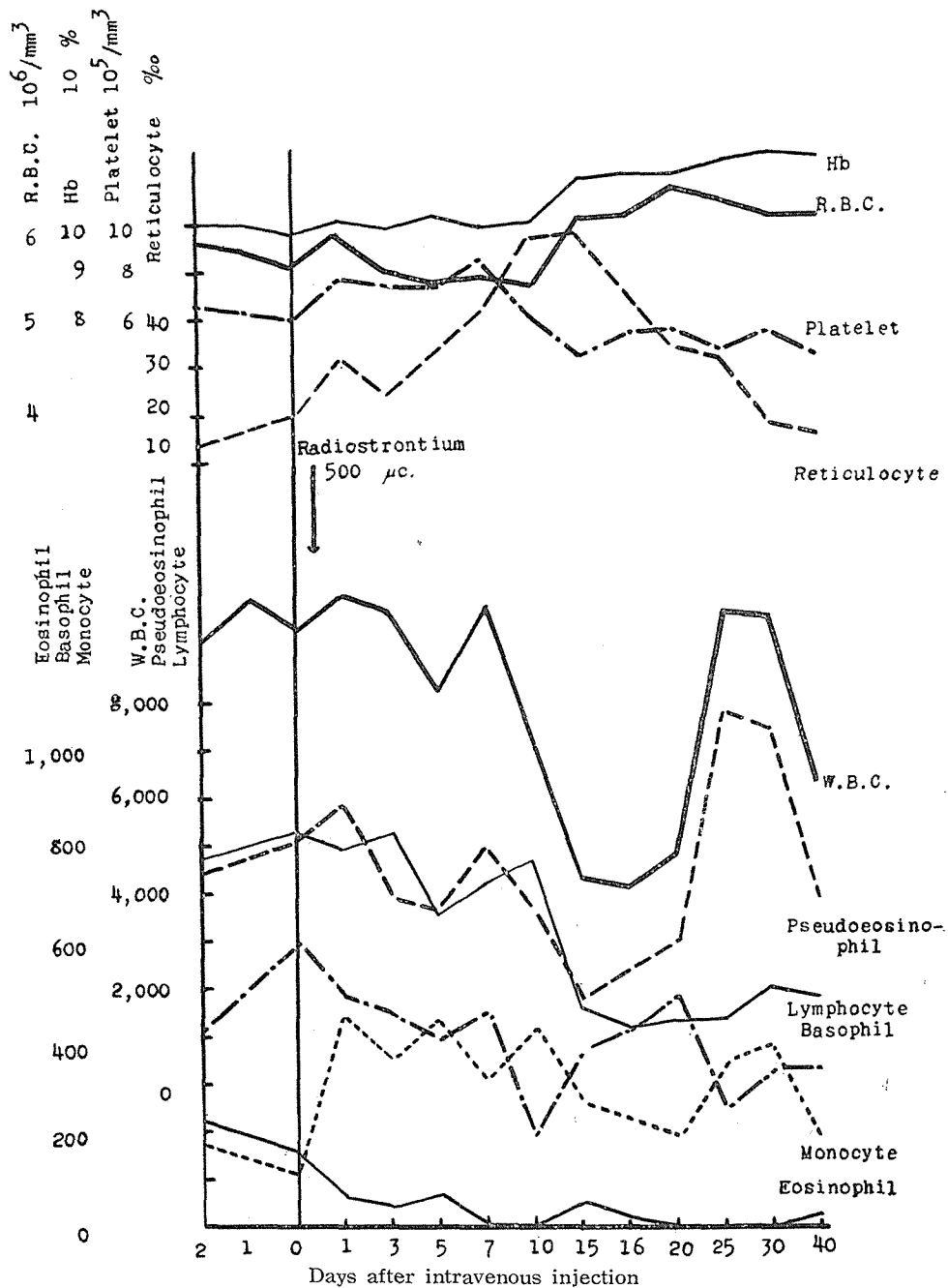
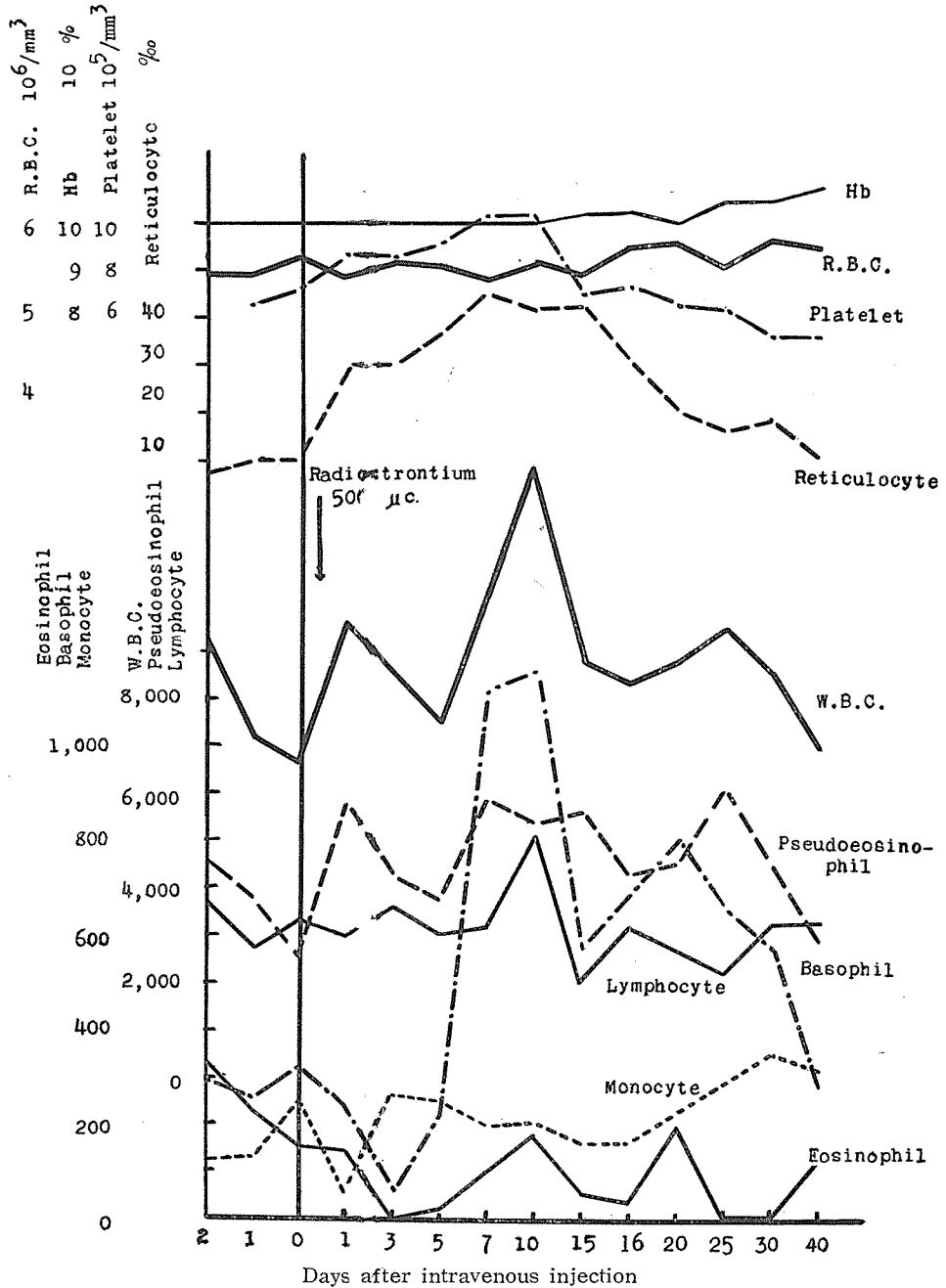


Fig. 2. Changes of the blood picture of rabbits following intravenous injection of 500 μ c. of $\text{Sr}^{89,90}$ (Rabbit No. 2)



Influence of Radiostrontium upon the Blood and Bone Marrow Picture.

ease, while the basophils increased temporarily in percentage in the third week. In the other case (No. 2) there was no remarkable change in the differential count except an increase of the basophils both in percentage and absolute number in the second and third week. The monocytes showed no remarkable change in both cases.

The platelet count showed a temporary increase in the first week and then show-

Table 3. Changes of the bone marrow picture of rabbits following intravenous injection of 500 μ c. of Sr ^{89,90} (Rabbit No. 1)

Time		Before injection	Days after injection			
			7	15	25	40
Number of nucleated cells (10 ⁴)		20.0	17.1	24.0	21.0	8.2
Erythropoiesis	Pronormoblasts	0.4	2.0	0.8	0.6	0
	Macroblasts					
	Basophilic	4.0	12.4	3.6	2.0	2.8
	Polychromatic	0.4 } 4.4	3.2 } 15.6	6.4 } 10.0	3.2 } 5.2	2.0 } 4.8
	Orthochromatic	0	0	0	0	0
	Normoblasts					
	Basophilic	3.6	22.0	6.8	6.0	2.4
	Polychromatic	47.6 } 61.2	149.6 } 174.8	172.4 } 183.4	151.2 } 165.2	51.2 } 54.8
	Orthochromatic	10.0	3.2	4.2	8.0	1.2
	Total	66.0	192.4	194.2	171.0	59.6
Leukopoiesis	Myeloblasts	1.4	2.4	0.4	0.6	1.6
	Pseudoeosinophilic					
	Promyelocytes	5.8	3.6	1.6	1.4	2.6
	Myelocytes	10.0 } 29.0	6.4 } 19.0	3.2 } 11.4	3.2 } 10.0	4.8 } 18.6
	Metamyelocytes	13.2	9.0	6.6	5.4	11.2
	Staff cells	32.8	37.0	32.6	38.8	36.8
	Polymorphonuclears (2 lobes)	8.6 } 42.4	9.2 } 47.2	13.6 } 47.0	12.6 } 52.0	9.8 } 47.2
	" (3 lobes)	1.0	1.0	0.8	0.6	0.6
	Total	71.4	66.2	58.4	62.0	65.8
	Eosinophilic					
	Promyelocytes	0	0	0	0	0.2
	Myelocytes	1.2	0	0	0	0.2
	Metamyelocytes	0.4	0	0	0.2	0.2
	Staff cells	0.8	0	0.2	0	0
	Polymorphonuclears	0.6	0	0.4	0	0.4
	Total	3.0	0	0.6	0.2	1.0
	Basophils	2.6	3.4	3.2	2.2	3.2
	Monocytes	2.8	8.0	4.8	5.8	7.0
	Lymphocytes	18.8	20.0	33.0	29.2	21.4
	Plasma cells	0.6	0.2	0.4	1.0	0.2
	Reticulum cells	0.2	0.6	0.2	0.6	1.6

ed a tendency to decrease in both cases.

2) Bone marrow picture (Tables 3, 4).

In one case (No.1) the number of nucleated cells showed a tendency to decrease 40 days after the injection, while in the other case (No.2) the number of nucleated cells showed a fluctuation throughout the observation period. The erythropoietic

Table 4. Changes of the bone marrow picture of rabbits following intravenous injection of 500 μ c. of Sr ^{89,90} (Rabbit No.2)

Time			Before injection	Days after injection					
				3	7	15	25	40	
Number of nucleated cells (10 ⁴)			4.5	14.9	6.9	24.0	40.0	8.5	
Erythropoiesis	Pronormoblasts		0.2	1.0	0.4	0.2	0.2	0.2	
	Macroblasts	Basophilic	2.0	2.2	1.8	3.2	0.6	3.2	
		Polychromatic	1.8 } 3.8	0.2 } 2.4	3.2 } 5.0	2.0 } 5.2	1.0 } 1.6	2.0 } 5.2	
		Orthochromatic	0	0	0	0	0	0	
	Normoblasts	Basophilic	2.8	7.6	3.8	7.8	1.4	4.2	
		Polychromatic	36.2 } 40.2	66.8 } 75.0	41.2 } 45.2	53.4 } 64.2	40.0 } 43.0	34.4 } 39.8	
		Orthochromatic	1.2	0.6	0.2	3.0	1.6	1.2	
	Total		44.2	78.4	50.6	69.6	44.8	45.2	
	Myeloblasts			0.6	2.2	1.2	0.6	2.0	1.0
	Pseudoeosinophilic	Promyelocytes	3.0	3.8	4.2	2.4	5.0	2.0	
Myelocytes		5.8 } 21.6	7.6 } 23.4	5.6 } 18.6	7.6 } 20.4	13.0 } 33.4	7.8 } 21.0		
Metamyelocytes		12.8	12.0	8.8	10.4	15.4	11.2		
Staff cells		33.4	42.0	34.4	40.0	42.6	44.0		
Polymorphonuclears (2 lobes)		10.8 } 46.2	10.0 } 53.4	14.2 } 49.6	14.6 } 56.0	4.0 } 46.8	10.8 } 55.2		
// (3 lobes)		2.0	1.4	1.0	1.4	0.2	0.4		
Total		67.8	76.8	68.2	76.4	80.2	76.2		
Eosinophilic	Promyelocytes	0.2	0	0.4	0	0	0		
	Myelocytes	0.2	0.2	0.2	0.2	0.4	1.2		
	Metamyelocytes	0.2	0.2	0.4	0	0	0.4		
	Staff cells	0.2	0	0.2	0	0	0.6		
	Polymorphonuclears	0.8	0	0	0	0	0		
	Total	1.6	0.4	1.2	0.2	0.4	2.2		
	Basophils			1.8	1.8	4.0	1.2	1.0	0.6
Monocytes			3.6	4.4	3.0	4.6	4.0	5.8	
Lymphocytes			24.6	14.4	22.4	17.0	12.4	14.2	
Plasma cells			0.2	0.4	0.6	0.2	0.8	0.2	
Reticulum cells			1.0	0.6	0.2	0.6	0.2	0.8	

Influence of Radiostrontium upon the Blood and Bone Marrow Picture

series were increased after the injection in both cases, especially in case No.1. In case No.1 the increase of the immature erythroblasts, such as basophilic and polychromatic macroblasts and normoblasts was especially marked. With regard to the white blood cells, there was a decrease of the immature pseudoeosinophils, such as promyelocytes, myelocytes and metamyelocytes in one case (No. 1) following the injection. This decrease was especially marked at 15 and 25 days after the injection, when there was a moderate leukopenia in the peripheral blood. In the other case (No. 2) no remarkable change was observed in the pseudoeosinophils. The eosinophils were decreased and the basophils were increased following the injection in both cases.

SUMMARY

- 1) The effects of the intravenous injection of 500 μ c. of radiostrontium upon the blood and bone marrow pictures of rabbits have been observed for 40 days.
- 2) Following the injection a moderate leukopenia and slight thrombocytopenia in the peripheral blood and a decrease of the immature pseudoeosinophils in the bone marrow were observed, which might suggest the suppressing effect of the radiostrontium upon the bone marrow.
- 3) The basophils were increased following the injection.

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